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MAX1340 12-Bit, Multichannel ADCs/DACs Single-Event Effects Characterization Test Report Using Heavy Ions

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1. INTRODUCTION

This study is to characterize the destructive single event latchup (SEL) susceptibility of the MAX1340 analog/digital converter (ADC) or digital/analog converter (DAC). The device was monitored for SEL current events on the power supplies during exposure to a heavy ion beam at Lawrence Berkeley National Laboratory (LBNL) 88-inch Cyclotron. Testing was performed on November 9, 2022.

2. DEVICES TESTED

2.1. Part Background

The MAX1340 integrate a multichannel, 12-bit, analog to digital converter and a quad 12-bit digital to analog converter in a single IC [1]. The MAX1340 includes a temperature sensor and configurable general-purpose I/O ports with compatible serial interface.

2.2. Device Under Test (DUT) Information

Ten (10) parts of MAX1340s were provided for heavy ion testing. Eight devices were decapsulated, and two devices were used as controls. Due to testing constraints only two devices were tested under heavy ion beam conditions. All specifications and descriptions are according to the MAX1340 datasheet. More information can be found in Table 1.

Table 1. Part Identification Information

Part Number	MAX1340
REAG ID#	22-015
Manufacturer	Maxim
Lot Date Code	n/a
Quantity Tested	10
Part Function	ADC/DAC
Part Technology	BiCMOS
Package	36 TQFN

An image of the MAX1340 die can be seen in Figure 1.

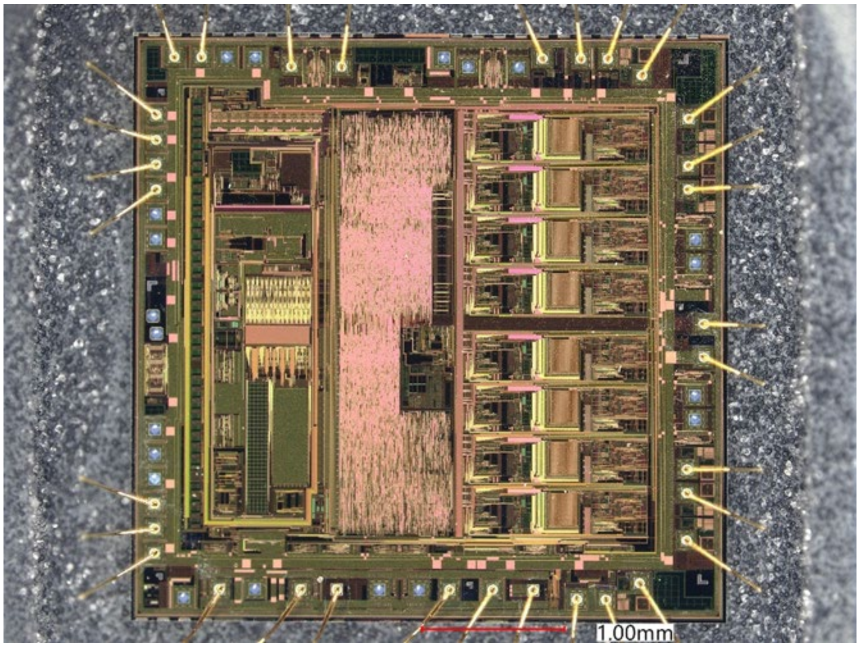

Figure 1: MAX1340 die

3. Test Setup

The test circuit for the MAX1340 were built to model/approximate the intended application. Figure 2 shows the circuit diagram implemented on the PCB and table 2 states the values for the electrical components.

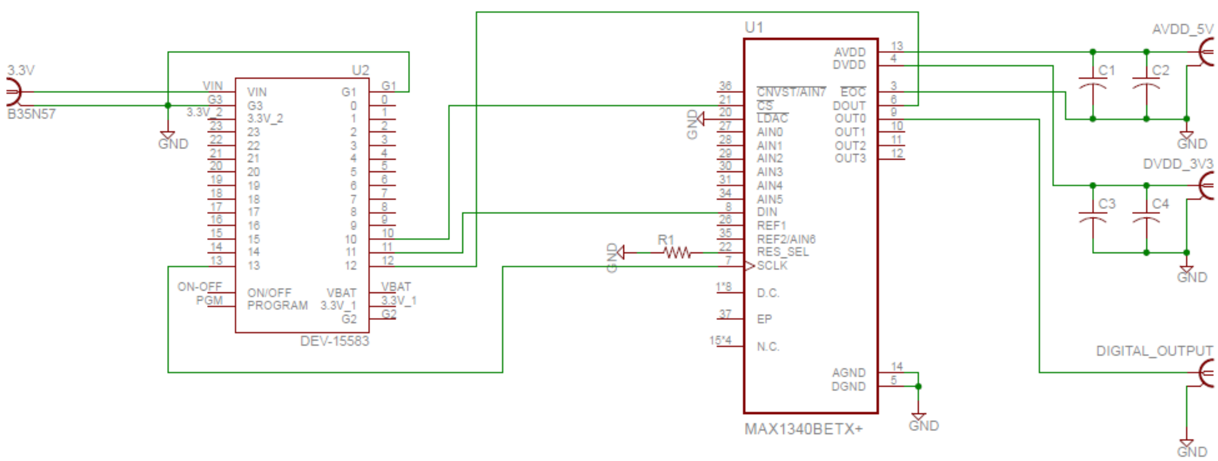

Figure 2: Schematic of the MAX1340 test circuit.

Table 2: List of Electronic Components

Component	Value
C1	0.1nF
C2	1000pF
C3	0.1µF
C4	1µF
R1	100kΩ

The test setup required a DC power supply, an oscilloscope for capturing the current, and a laptop quipped with LabVIEW for saving the data. Parts were serialized randomly. Figure 3 shows a block diagram of the experiment setup and Figure 4 shows a device under test (DUT) on the PCB in the beamline.

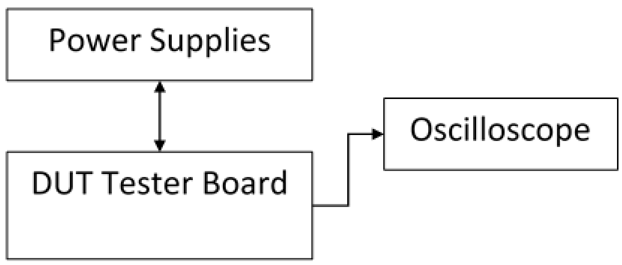

Figure 3: Block Diagram

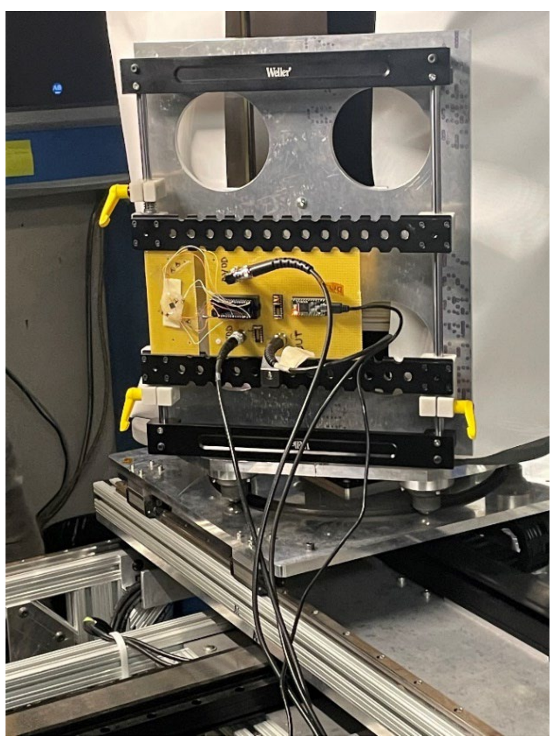

Figure 4: Experiment Test Set-up

The following equipment listed in table 3 will be used to create the test circuit:

Table 3: List of Necessary Equipment

Make	Model	NASA ECN	Comments
Tektronix	DSA 72004	2173383	Oscilloscope
Agilent Technologies	N6702A	M161871	Power supply
Mounting board	N/A	N/A	Mounting board
Cables	N/A	N/A	Cables to make connections

Power supply currents were continually monitored for SEL. Current was logged to capture latch up events, and any increase would indicate latch up had occurred. When latch up occurred, currents were returned to normal after a power cycle was performed if possible. The DUT was operated in a digital to analog mode as seen in figure 5.

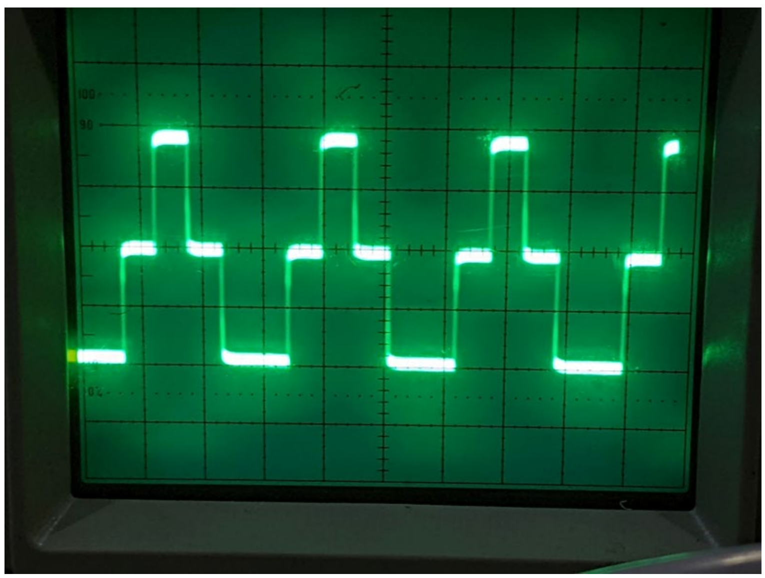

Figure 5: Digital to Analog Function

4. Test Facility

SEE testing is done by exposing a decapsulated die to heavy ions to see the radiation response over varied Linear Energy Transfer (LET). This is done by utilizing different species of ions, one at a time to capture the cross section of that device at each LET to characterize the device.

Facility: Lawrence Berkeley National Laboratory 88” Cyclotron Facility, 16 MeV/amu in air
Flux: 1 x 10^3 to 1 x 10^5 particles/cm^2/s
Fluence: All tests will be run to the lesser of 1 x 10^7 ions/cm^2 or a destructive event occurs
Ion Species: Table 3 shows the surface-incident beam properties

Table 3: Notional Energy, Range, and LET* Estimates for Accelerated Ions at 16 MeV/amu**

Ion	Tilt Angle (°)	Energy (MeV)	Range (µm)	Nominal Incident LET (MeV-cm2/mg)
^{18}Ar	0	546	201.6	8.07
^{23}V	0	624	150.1	13
^{29}Cu	0	788	137.1	18.9

* LET: Linear Energy Transfer (MeV/mg/cm^2)

4.1. Test Conditions and Error Modes

Test Temperature: Room
Vacuum: No
Digital Positive Power Input: 3.3V
Positive Analog Power Input: 5V
Error Modes: The primary purpose of this test to identify destructive single event effects. All events will be captured by the oscilloscope

6. Test Personnel

Personnel: Tom Carstens (NASA), Michael Campola (NASA), and Anthony Phan (SSAI)

7. Test Results

Initially the MAX1340 was irradiated with Ar ions (LET of 8.07 MeV-cm^2/mg). During heavy ion irradiation the DUT did not experience any destructive single event effects. This is seen in Figure 5 where the currents for the digital and analog inputs showed no large current spikes. This device was exposed to a fluence of 1.00x10^7 cm^{-2} without any single event effects.

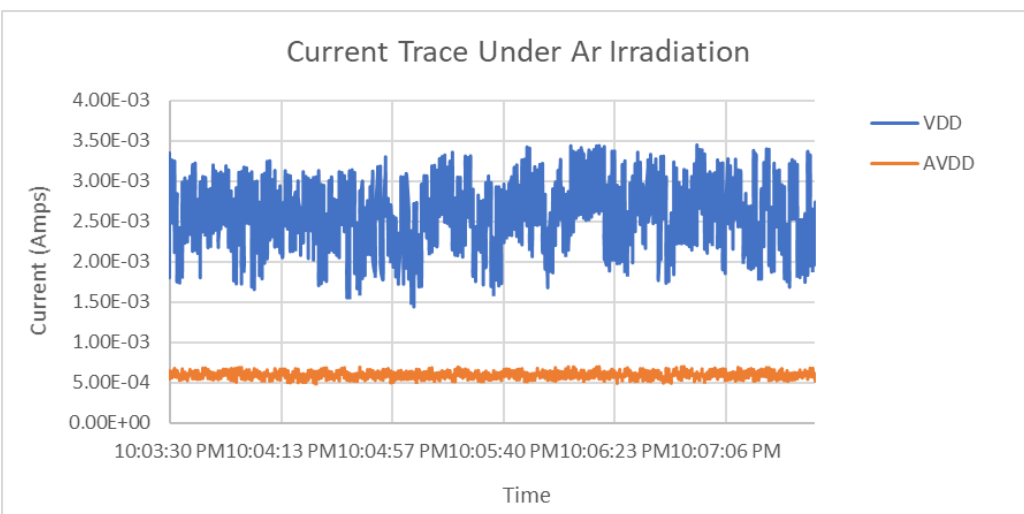

Figure 5: MAX1340 Current During Argon Irradiation

During irradiation with V ions (LET = 13 MeV-cm^2/mg), the MAX1340 experienced latch up, as seen in Figure 6. This event occurred at a fluence of 1.18x10^6 cm^{-2}. After the current spike the beam was shut down, and the DUT was power cycled. After this power cycle the MAX1340 returned to normal operations.

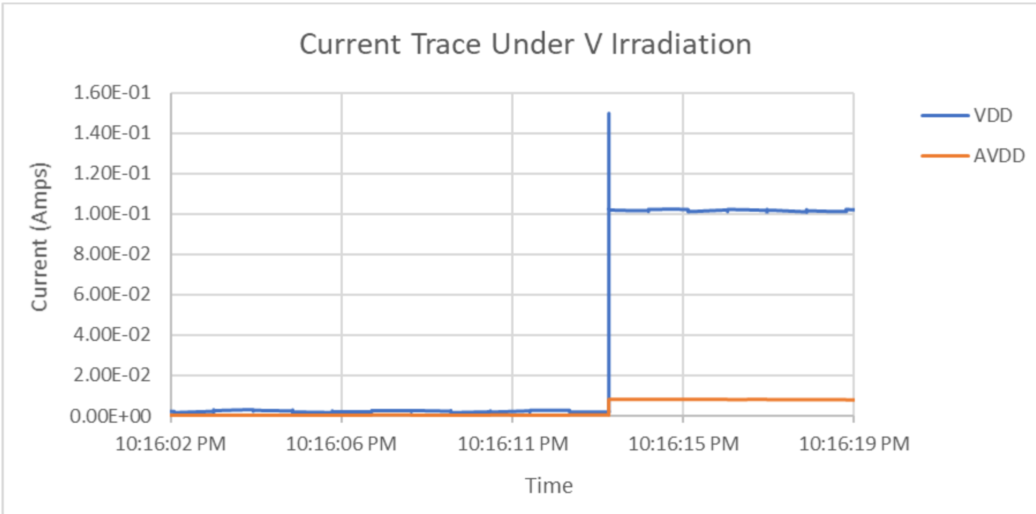

Figure 6: MAX1340 Current During Vanadium Irradiation

During heavy ion irradiation with Cu (LET = 18.9 MeV-cm^2/mg) the MAX1340 experienced destructive latch-up. This can be seen in Figure 7 where the currents for VDD and AVDD experienced a sharp increase in current. This occurred at a fluence of 2.94x10^5 cm^{-2}. The current remined in the high state after a power cycle of the DUT confirming the latch up was destructive.

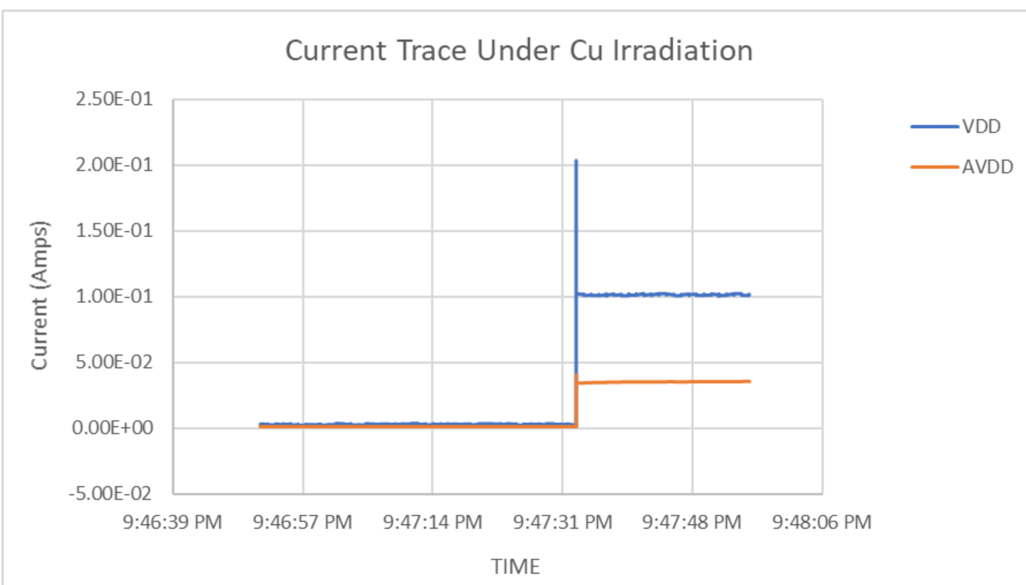

Figure 7: MAX1340 Current During Copper Irradiation

8. SUMMARY

The MAX1340 did not experience any destructive single-event effects during heavy ion irradiation at a normal-incidence linear energy transfer (LET) of 8.07 MeV-cm^2/mg under room temperature conditions and a fluence of 1.00×10^7 cm^{-2}. At a LET of 13 MeV-cm^2/mg the device experienced non-destructive latch up. The device was able to return to normal operations after a power cycle. At a LET of 18.9 MeV-cm^2/mg the MAX1340 experienced destructive latch up at a fluence of 2.94×10^5 cm^{-2}.

9. REFERENCES

[1] Maxim, "12-Bit, Multichannel ADCs/DACs with FIFO, Temperature Sensing, and GPIO Ports", MAX1340 datasheet, March 2008.